Error in Cadmium Determinations Due to Adsorption by Filter Papers

by M. K. JOHN and C. J. VANLAERHOVEN

Science Policy Branch, Environment Canada, Ottawa, Ontario K1A OH3
and
Research Branch, Agriculture Canada
Agassiz, British Columbia VOM 1AO

Cadmium has been acknowledged as one of the most hazardous environmental pollutants. Excessive inhalation and dietary intake of cadmium have been related to the incidence of cardiovascular and pulmonary diseases and the endemic "ouch-ouch" in Japan (SCHROEDER et al, 1967; NANDI et al, 1969; TSUCHIYA, 1969). Scientific attention to cadmium in the environment and its transfer to man and animals has prompted numerous determinations of cadmium concentrations for a wide variety of materials including airborne particulates, soils, waters, fertilizers, plants, foods, and animal and human tissues. The analytical methods include extractions, acid digestions, evaporation to dryness, final acquisition of aqueous solutions, collection of gases in water, and filtration before measurement of cadmium content. During studies of soil and plant cadmium conducted by our research laboratory, cadmium in solution was apparently lost during filtration unless precautions were taken (JOHN, 1971; JOHN et al, 1972).

Materials and Methods

Standard solutions containing 0, 1, 5 and 10 ppm Cd were prepared with deionized distilled water by dilution of an atomic absorption spectrophotometry standard solution of cadmium chloride. Aliquots of each standard solution were collected in acid-washed funnel tubes after passing through 9.0 cm diameter filter discs of Whatman No. 42 and No. 2 filter papers. Whatman No. 42 papers are acid-washed, ashless (ash content 0.01%), slow filtering, very retentive (not passing barium sulfate), and fine textured. The No. 2 filters are qualitative grade, have low ash content, and are of medium texture and retentiveness. For four other sets of the standards, a drop of 6N hydrochloric acid, 6N sodium hydroxide, N ammonium acetate, or 6N nitric acid was added to a 20-ml aliquot of each standard solution before filtration. Using calibration standards of approximately the same composition to compensate for background absorption, cadmium in filtrates was determined by atomic absorption at a wavelength of 288.8 nm.

Results and Discussion

Cadmium concentrations in standard solutions and filtrates obtained from various filtration methods are given in Table I.

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No cadmium was detected after 1 ppm Cd solution filtered through No. 42 paper and only 0.20 ppm Cd remained after the standard solution passed through the No. 2 filter. The percentage losses of cadmium from the 5 ppm standard were 58 and 48% for the No. 42 and No. 2 filter papers, respectively. For the 10 ppm Cd solution, however, filtering with No. 2 paper caused a greater loss of cadmium (44%) than with No. 42 paper (36%). Concurrent investigation involving agitation of cadmium chloride solutions in glassware and polyproylene tubes, sealed by rubber stoppers or plastic laboratory film, indicated that no cadmium was lost from solution. Decreased concentrations after filtration were attributed to cadmium adsorption in the filter paper. Since filter discs are composed mainly of organic compounds, this finding agrees with enhanced adsorption of cadmium and other heavy metals found in association with increased organic matter content of soils (JENNE, 1968; JOHN, 1971).

TABLE I

Cadmium Concentration in Standard Solutions and After Filtration by Various Methods

Standard solution	Filtered only		Added HCl and filtered	
	No.42	No.2	No.42	No.2
	(ppm Cd in solution)			
1.00	0.00	0.20	1.01	1.08
5.00	2.10	2.59	5.05	5.19
10.00	6.43	5.60	10.08	10.31

Adsorption of cadmium by filter and subsequent loss from the solution prior to measurement should be eliminated to obtain accurate results. The problem of filter paper adsorption was overcome by adding a drop of 6N hydrochloric acid to 20-ml aliquots before filtration (Table I). Similarly, addition of sodium hydroxide, ammonium acetate, or nitric acid also eliminated the cadmium adsorption by the filters (not tabulated).

These results indicated that adsorption of cadmium from aqueous solution by filter papers caused substantial error in determinations of the element in filtrates unless adequate amounts of acid, base, or electrolyte were present in solution. Analytical methods, involving filtration of aqueous solutions prior to cadmium determination, are therefore subject to error unless precautions are taken to avoid the adsorption by filter papers.

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